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ABSTRACT

A cross-sectional study that investigated memory variables in 100 subjects in 4 age ranges (17-22, 40-50, 60-70, and 75-99) found that the 60-70 year olds were more impaired with respect to retrieval than storage and the major problem with memory among the 75-99 year olds was retrieval from short- or long-term memory. Because the study was cross-sectional, differences among the age groups do not necessarily reflect changes with age. Memory tasks in the study included the following: free recall, serial recall, delayed serial recall, and judgment of relative frequency of words, labels, digits, and events. Research participants were tested individually in two sessions in the participants' own homes or in a central location such as a testing room in a senior center, civic center, school, or motel. Each session included 12 tests. Factor analyses of variables were run separately for each age group. The principal components method was used, with varimax rotation, computed separately for each age group with the sexes combined. The first four factors accounted for about half the variance in each age group. The effects of age and sex on memory were assessed by using age group and sex as sources of variance in analyses of variance, with t-tests following up significant overall effects. (CML)

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Incidental and Intentional Memory in Adulthood and Old Age

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This report deals with part of the data collected in a large-scale cross-sectional study in which 400 adults were given a battery of 24 questionnaires, tests, and tasks that yielded scores on well over a hundred different variables, including memory, learning, problem solving, reasoning, thinking, intelligence, and demographic characteristics. This report covers all the memory variables that were assessed.

Method

Research Participants

We tested about 100 research participants in each of four age ranges that we selected on the basis of Juan Pascual-Leone's (1983, 1984) taxonomy of styles of thinking in adulthood and old age. We had several measures of style of thinking; but they are not reported here, so we will refer to the age groups as young, middle-aged, old, and old-old. The actual age ranges, to the last birthday, were 17-22, 40-50, 60-70, and 75-99. Because the study was cross-sectional, differences among the age groups do not necessarily reflect changes with age. For expository convenience, however, we will sometimes refer to age group differences as "age changes."

Variables

Memory variables. We obtained scores on 21 memory variables from 8 tasks, interspersed among the other tasks in two testing sessions. The memory tasks are listed in Table 1, but not in their order of presentation.

(1) For the Word-List Memory task, a list of 16 words was presented, with four words from each of four categories and with free recall instructions. We used a procedure developed by Buschke (1977) to provide a direct assessment of clustering in free recall, and we also assessed serial position effects. Scores on seven variables were obtained: Free recall of words, clustering of words, primacy (recall from the first four positions in the list), middle (middle four positions), recency (last four positions), lag-7 recency (number of words recalled with lags of 7 or fewer items intervening between the presentation of the word for study and the recall of the word), and intrusions.

(2) and (3) We gave the two Digit Span tests from the WAIS-R (Wechsler, 1981). One assesses forward serial recall of digits and the other assesses backward serial recall of digits.

(4) The Delayed Digits Recall task required serial recall of 5 digits in an intentional memory task. Between the presentation of the digits for study and the recall test, the participant read a list of 81 words. Three variables were assessed: Absolute correct serial recall (digits recalled in their exact serial position), relative correct serial recall (digits recalled in their correct serial position relative to other digits that were recalled), and free recall (digits correctly recalled disregarding serial position).

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(5) The Frequency Judgment task involved the 81-word list in the preceding task. The list contained 36 different words repeated various numbers of times. In a surprise memory test, the research participant was presented pairs of words and was asked which word in each pair occurred more often in the list. This was an incidental memory task, that is, it was given without prior warning; it yielded one score, frequency judgment.

(6) The Event-List Memory task was also an incidental memory task. One of our tasks assessing style of thinking involved reducing a set of 32 life events to one target event by successive halving--reducing the list of 32 events to two sets of 16, reducing the 16 that included the target event to 8, reducing the 8 that included the target event to 4, reducing the 4 that included the target event to 2, and reducing the 2 to the 1 target event. (The idea for the task came from Plato's method of definition by divisions.) The events were identified with brief labels, such as "job promotion" and "heart attack." We gave each participant two versions of the task, one in each testing session, with different events in each version. After the second version we gave an unannounced test of memory for the events in that version, using the Buschke procedure for assessment of clustering of the items. Thus, the Event-List Memory task provided assessments of four variables: Free recall of event labels, clustering of event labels, intrusions from the Session 1 version, and other intrusions.

(7) Temporal Order I: In a surprise memory test at the end of the first session, the research participant was given the names of the tasks that had been presented in that session and one card labeled "Break" for each break that was taken, and was asked to put the cards in the sequence of occurrence. Performance was scored for both absolute and relative correct serial ordering.

(8) Temporal Order II: The research participant was told at the beginning of the second session that a test of memory for the temporal order of the tasks presented in the session would be given at the end of the session. Otherwise, the test at the end of Session 2 was the same as the test at the end of Session 1; both absolute and relative correct serial ordering were assessed. This was formally an intentional memory task, in that the participants were told that memory would be tested; but it was most likely an incidental memory task functionally: The research participants were never reminded during the session about the memory test to be given at the end, the times between tasks were long, and the number of tasks was large.

Demographic variables. We examined 10 demographic variables for this report. They are summarized in Table 2. (1) The mean ages were about 20, 44, 66, and 80. Thus, although the age ranges were not the same in the four groups and the age gaps between the groups were unequal, the gaps between the mean ages were more nearly equal. (2) About half of each group were females (by design); (3) most of each group lived in cities with populations of 70,000 or more; (4) all the groups averaged slightly more than a high school education; (5) most of the young adults were students and were otherwise unemployed, and most of the other adults had present or past careers in service (which includes sales) or the professions; and (6) on average all the groups reported good, but not excellent health. (7) Depression was measured with the Center for Epidemiological Studies Depression Scale (U. S. Department of Health, Education and Welfare, 1980). On average all the groups reported little depression, although the youngest group reported significantly more depression than the older groups. (8)

Crystallized intelligence was measured with the vocabulary test from the WAIS-R (Wechsler, 1981). It was significantly lower in the young group than in the middle-aged and old groups, but the other age group differences were nonsignificant and all the differences were small. (9) Fluid intelligence was measured with an inductive reasoning test (Letter Sets in the Eckstrom, French, Harman, & Derman, 1976, kit); and (10) intellectual speediness was measured with the Finding A's test (Eckstrom et al., 1976). Both fluid intelligence and intellectual speediness declined markedly across the age groups, replicating usual longitudinal trends of little or no change in crystallized intelligence and marked declines in fluid intelligence and intellectual speediness.

In short, the samples turned out to come from fairly standard middle-class urban backgrounds, with moderately good education and normal intelligence.

Procedure

The research participants were tested individually in two sessions and were paid $10 for each session completed. The testing was done in the participant's own home or in a central location such as a testing room in a senior center, civic center, school, or motel. Each session included 12 tests (including those not reported here), given in a fixed order selected to minimize fatigue and transfer of effects between tasks, and to avoid, insofar as possible, failure on a series of tests.

Results and Discussion

Factor Analyses

Factor analyses of the 21 memory variables were run separately for each age group in order to assess age-group differences in the structure of memory. The principal components method was used, with varimax rotation, computed separately for each age group with the sexes combined. The first four factors accounted for about half the variance in each age group; therefore, only these factors were rotated. Variables with factor loadings of .50 or more were used to interpret the rotated factors.

All but four of the memory variables appeared in one or another of the four factors in at least one age group. The four that did not appear in any factor were frequency judgment and the three measures of intrusions.

1. One factor, obtained in the young and old-old groups, included the three variables from the Delayed Digits Recall task: As shown in Table 3, the variables were the numbers of digits correct as scored in free recall, absolute serial recall, and relative serial recall. This factor involves deliberate long-term memory for digits.

A similar factor was obtained in the middle-aged group, but with the two Digit Span variables added (digit span forward and backward). This expanded factor was also obtained in the old group, except that the loading for digit-span backward (.47) did not meet the .50 criterion. The Digit Span tasks involve deliberate short-term memory for digits; therefore, including them changed the interpretation of the factor from deliberate long-term memory for digits to deliberate short- and long-term memory for digits.

2. A second factor consisted of the two recency variables from the Word-List Memory task. Recency involves retrieval of words from short-term memory, and other research indicates that it reflects a deliberate retrieval strategy. This factor was obtained in all four age groups, except that in the old group it included the primacy score, negatively loaded, from the same task. The primacy score reflects deliberate processing; therefore, the negative loading of the primacy score indicates that for the old group this factor includes absence of primacy. Apparently, for the old group this factor indicates that the deliberate retrieval strategy is used <u>at the expense of</u> using a deliberate storage strategy.

3. A third factor, which was obtained in the young and middle-aged groups, consisted of the four temporal-order variables and two variables assessed on the Event-List Memory task: The variables were absolute and relative correct recall of the serial ordering of the tasks in Sessions 1 and 2, and total correct and clustering in free recall of the life events used in the Divisions task. The tasks involved incidental memory; therefore, this factor involves automatic encoding of characteristics of events--temporal order of tasks as events, and names of life events.

In the old and old-old groups, the analogous factor included the four temporal-order variables but not the two Event-List Memory variables. Thus, for the old and old-old adults, this factor involves serial recall of events. Apparently, for the young and middle-aged groups the factor reflects a particular set of mental processes, and for the old and old-old groups it reflects task demands. The distinction is similar to the distinction in perception between conceptually driven or top-down processing (for the two younger groups) and data-driven or bottom-up processing (for the two older groups). That is, for the two younger groups performance was driven by automatic storage operations, and for the two older groups it was driven by the retrieval demands of the task, which were presumably dealt with by the use of deliberate strategies for retrieval of serial order from long-term memory. Presumably, the serial-order information was stored automatically, when it was stored at all.

4. A fourth factor, obtained in the young and middle-aged groups, included four variables from the Word-List Memory task: Number correct in free recall, clustering, primacy items correct, and middle items correct. This in an intentional memory task, and the clustering variable and the two serial-position variables presumably reflect deliberate operations. Therefore, this factor involves deliberate storage of words, specifically, deliberate storage in long-term memory because the recency variables for this task constitute a different factor (Factor 2).

For the old group, the analogous factor included the same variables plus the two Event-List Memory variables that dropped out of Factor 3. Therefore, the factor could be interpreted to involve deliberate storage of words plus automatic storage of events. However, a more plausible interpretation is possible because all the variables were derived from free-recall tasks: For the old group this factor involves free recall of words.

For the old-old group, the factor was the same as for the old group except that the factor loading for the clustering variable (.33) did not meet our .50 criterion. Nevertheless, the factor can be interpreted in the same way as for the old group. Therefore, like Factor 3, this factor

reflects a particular set of mental processes for the young and middle-aged groups and it reflects task demands for the old and old-old groups. For the two younger groups, performance was driven by deliberate storage operations and for the two older groups it was driven by the retrieval demands of the task, which presumably were dealt with by the use of deliberate retrieval strategies. As in the younger groups, retrieval was evidently from long-term memory; but unlike the younger groups, in which storage was deliberate, in the older groups the manner of storage was irrelevant.

Analyses of Separate Memory Variables

The effects of age and sex on memory were assessed by using age group and sex as sources of variance in analyses of variance of the memory variables, with *t* tests following up significant overall effects. Mean scores on the memory variables are presented in Tables 4 and 5, with symbolic summaries of the analyses of variance. No age by sex interaction was significant, main effects of sex were rarely significant, and all but one of the main effects of age were significant. As shown in Table 4, frequency judgment was more accurate in the young and middle-aged groups than in the old and old-old groups, but accuracy was good (74%) even in the older groups. Intrusions were rare and age differences were negligible even when statistically significant.

Table 5 shows the age group means organized by factors. On the Delayed Digits task in Factor 1, free recall was better than serial recall; none of the adjacent age groups differed significantly on the free recall measure; and the difference between the middle-aged and old groups was not significant for any of the variables in this factor. The general trend for the variables involving measurement of serial recall--and for Factor 1 as a whole--was decline from young to middle-age, followed by a plateau and then decline from old to old-old age. The largest drop was between old and old-old age.

These trends are clearer in Table 6, which shows differences between adjacent age groups. Evidently, deliberate storage of a short list of digits is much more successful than deliberate storage of the serial order of the digits. However, Factor 1 as a whole refers to recall of digits disregarding scoring method; and the age trend implies that the skills involved, which are deliberate and specific to digits, decline when formal schooling ends (after young adulthood in our study) and these skills declined again between old and old-old age.

For Factor 2 the overall trend was decline beginning in middle age. The deliberate use of the short-term store in a memory task is learned, according to other research, and the age trend therefore suggests that before old age it is learned fairly rapidly or, once learned, is used effectively, but that during old age it is learned progressively more slowly or, once learned, is used progressively less effectively with increasing age.

The large drop from old to old-old age indicates that old-old adults have problems with deliberate retrieval of words from short-term memory (Factor 2) as well as deliberate delayed recall of digits (Factor 1, which includes only delayed recall of digits in the young and old-old groups). Perhaps for old-old adults, the problem with delayed recall of digits reflects a change in the meaning of Factor 1: For the young adults, Factor 1 reflects deliberate storage of digits for delayed recall; for the middle-

aged and old adults, it reflects deliberate storage of digits for immediate or delayed recall; and for the old-old adults, it reflects deliberate retrieval of digits from long-term memory. If so, then the sharp decline between old and old-old age in Factors 1 and 2 is attributable to one source: problems with deliberate retrieval--from both short- and long-term memory--in old-old age.

For Factors 3 and 4 the overall trend was marked decline across all age groups. The factors differ in many ways; for example, Factor 3 refers to labels for events and Factor 4 refers to words and, for the two older groups, events; Factor 3 refers to automatic processes for the two younger groups and deliberate processes for the two older groups and Factor 4 refers to deliberate processes for all groups; and Factor 3 becomes a serial recall factor in the older groups and Factor 4 becomes a free recall factor. However, these factors are the same in that their content changes from storage processes to retrieval processes.

One way to interpret the factors is with respect to whether they involved intentional or incidental memory tasks. As shown in Table 7, Factors 1 and 2 involved only intentional memory tasks, Factor 3 involved only incidental memory tasks; and Factor 4 involved only intentional memory tasks for the young and middle-aged groups and involved both intentional and incidental memory tasks for the old and old-old groups. One problem with this way of interpreting the factors is the mixture of tasks in Factor 4 for the old and old-old groups. Memory cannot be both intentional and incidental, and therefore this factor is an anomaly for these groups. However, it is not anomalous according to the interpretation given before. Another problem with the intentional/incidental interpretation of the factors is that the marked age trend for Factor 3 was not replicated for the variables that were not included in any factors. These variables involved incidental memory, on the assumption that intrusions are not deliberately stored along with relevant items; but as seen in Table 4, they yielded negligible age trends.

In summary, then, the old group was more impaired with respect to retrieval than storage, in that they were more similar to middle-aged adults on Factors 1 and 2 than on Factors 3 and 4; and the major problem with memory in the old-old group seems to have been retrieval, whether of digits, words, or events, and whether from short- or long-term memory.

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Author Note

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Table 1
Memory Tasks and Variables

Task name	Type	Task	Variables
Word-List Memory	Intentional	Free recall of categorized list of 16 words	Free recall Clustering Primacy Middle Recency Lag-7 recency Intrusions
Digit Span Forward	Intentional	Serial recall of digits	Digit-span forward
Digit Span Backward	Intentional	Same as #2 except backward serial recall	Digit-span backward
Delayed Digits Recall	Intentional	Delayed serial recall of 5 digits, with delay filled	Absolute Relative Free recall
Frequency Judgment	Incidental	Judgment of relative frequency of words presented various numbers of times	Frequency judgment
Event-List Memory	Incidental	Free recall of labels of life events	Free recall Clustering Session-I intrusions Other intrusions
Temporal Order I	Incidental	Delayed serial recall of Session 1 tasks	Absolute Relative
Temporal Order II	"Intentional"	Delayed serial recall of Session 2 tasks	Absolute Relative

Table 2
Age Group Means on Demographic Variables

Variable	Age group: Young	Middle	Old	Old-Old	p
Number	100	92	113	95	--
Age mean	20.2	44.4	66.0	80.5	--
range	17-22	40-50	60-70	75-99	--
Sex (%)					--
Male	50	46	44	47	
Female	50	54	56	53	
Population					ns
0-10K	18	13	9	4	
30K-60K	9	16	12	15	
70K-100K	29	22	30	34	
120K +	44	49	49	47	
Education	13.2[a]	13.6[a]	13.3[a]	12.6[a]	ns
Career					.001
Pro/Exec	1	28	39	41	
Service	14	33	31	27	
Labor	1	15	17	18	
Stu/House	84	24	13	14	
Occupation (%)					.0001
Unemployed	55	29	6	2	
Employed	45	70	26	9	
Retired	0	1	68	89	
Health	2.0[a]	2.1[a]	1.8[b]	1.8[b]	.001
Depression	14.7	11.3[a]	9.8[a]	10.4[a]	.0001 F
Intelligence					
Crystal.	49.6[a]	56.4[b]	54.0[bc]	52.1[ac]	.01 M
Fluid	20.1	17.2	12.3	7.2	.0001 F
Speed	57.4[a]	54.6[a]	48.7	44.4	.0001

Notes. (1) The probabilities in the last column are for the main effect of age in age by sex analyses of variance or, for qualitative variables, the effect of age in chi-square analyses; a dash indicates that no statistical test was run. A capital letter following the p indicates a significant sex difference favoring females (F) or males (M). (2) Means with the same superscript letter were not significantly different from each other. (3) Health index: 0 = Poor; 1 = Fair; 2 = Good; 3 = Excellent. (4) Depression score: A high score (maximum = 60) indicates high depression.

Table 3
Factor Loadings of Variables on the Four Memory Factors

Variable	Age group			
	Young	Middle	Old	Old-old
Factor 1				
Delayed Digits				
Free recall	85	81	83	82
Absolute serial	92	92	92	92
Relative serial	90	90	93	93
Digit Span				
Forward	(46)	51	53	(31)
Backward	(49)	67	(47)	(26)
Factor 2				
Word-List Memory				
Recency	73	81	74	82
Lag-7 recency	76	83	77	80
Primacy	(-36)	(-25)	-60	(-13)
Factor 3				
Temporal Order I				
Absolute correct	61	78	76	50
Relative correct	71	79	70	61
Temporal Order II				
Absolute correct	66	62	78	79
Relative correct	66	62	80	74
Event-List Memory				
Total correct	64	65	(28)	(33)
Clustering	62	56	(10)	(43)
Factor 4				
Word-List Memory				
Total correct	84	87	90	81
Primacy	63	68	52	69
Middle	72	71	64	76
Clustering	73	89	83	75
Event-List Memory				
Total correct	(26)	(31)	63	50
Clustering	(20)	(40)	61	(33)

Notes. (1) The decimal point is omitted from the factor loadings. (2) Parentheses indicate that the variable was not in the indicated factor for the indicated age group.

Table 4
Age Group Means for Frequency Judgment and Intrusions

	Age group				
Variable	Young	Middle	Old	Old-Old	p
Frequency judgment %	81[a]	82[a]	74[b]	74[b]	.0001 F
Intrusions					
Word-List	.6[a]	.7[a]	.8[a]	1.2[a]	ns
Event-List					
Ses. I	.6	.4[a]	.2[a]	.2[a]	.001
Other	.6[a]	.9[ab]	1.1[b]	1.0[ab]	.02

Notes. (1) The probabilities in the last column are for the main effect of age in age by sex analyses of variance. The F following the p for Frequency Judgment indicates a significant sex difference favoring females. (2) Means with the same superscript letter were not significantly different from each other.

Table 5
Age Group Means on Memory Variables Organized by Memory Factors

Variable	Young	Middle	Old	Old-Old	p
		Age group			
Factor 1					
Delayed Digits					
Free recall	84[a]	80[ab]	72[bc]	66[c]	.0001
Absolute	66	56[a]	54[a]	38	.0001
Relative	72	62[a]	62[a]	46	.0001
Digit Span					
Forward	(8.7[a])	8.1[ab]	7.7[b]	(7.1)	.0001 M
Backward	(7.1)	6.4[a]	(6.5[a])	(5.6)	.0001
Factor 2					
Word-List					
Recency	2.4[a]	2.3[a]	1.8	1.5	.0001
Lag-7 rec.	2.2[a]	2.2[a]	2.0[a]	1.7	.001
(-) Primacy	(2.5[a])	(2.2[a])	1.7	(1.3)	.0001
Factor 3					
Temp. Order I					
Absolute	54	46	33	22	.0001
Relative	66	56	45	33	.0001
Temp. Order II					
Absolute	58	50	33	24	.0001
Relative	68	60	45	36	.0001
Event-List					
Total R+	46	41	(32)	(23)	.0001 F
Clustering	9.2	8.0	(6.0)	(3.8)	.0001
Factor 4					
Word-List					
Total R+	61	52	42	31	.0001
Primacy	2.5[a]	2.2[a]	1.7	1.3	.0001
Middle	2.3	1.8	1.5	1.0	.0001
Clustering	5.9	4.8	3.2	2.2	.0001
Event-List					
Total R+	(46)	(41)	32	23	.0001 F
Clustering	(9.2)	(8.0)	6.0	(3.8)	.0001

Notes. (1) The probabilities in the last column are for the main effect of age in age by sex analyses of variance. A capital letter following the p indicates a significant sex difference favoring females (F) or males (M). (2) Means with the same superscript letter were not significantly different from each other. (3) Parentheses indicate that the variable was not in the indicated factor for the indicated age group.

Table 6
Differences between Means of Adjacent Age Groups

Variable	Y - M	M - O	O - O-O
Factor 1			
Delayed Digits			
Free recall %	4	8	6
Absolute serial %	10*	2	16*
Relative serial %	10*	0	16*
Digit Span			
Forward	.6	.4	.6*
Backward	.7*	-.1	.9*
Factor 2			
Word-List Memory			
Recency	.1	.5*	.3*
Lag-7 recency	0	.2	.3*
Primacy (neg. load.)	.3	.5*	.4*
Factor 3			
Temporal Order I			
Absolute %	8*	13*	11*
Relative %	9*	11*	12*
Temporal Order II			
Absolute %	8*	17*	9*
Relative %	8*	15*	9*
Event-List Memory			
Total correct %	5*	9*	9*
Clustering	1.2*	2.0*	2.2*
Factor 4			
Word-List Memory			
Total correct %	9*	10*	11*
Primacy	.3	.5*	.4*
Middle	.5*	.3*	.5*
Clustering	1.1*	1.6*	1.0*
Event-List Memory			
Total correct %	5*	9*	9*
Clustering	1.2*	2.0*	2.2*
Frequency judgment	-1	8*	0

* $p < .05$

Table 7
Classification of Factors by Type of Memory Task

Task	Type	Age trend
Factor 1		
Delayed Digits	Intentional	Y > M = O >> O-O
Digit Span tasks	Intentional	Same
Factor 2		
Word-List Memory	Intentional	Y = M > O >> O-O
Factor 3		
Temporal Order I	Incidental	Y > M > O > O-O
Temporal Order II	Incidental	Same
Event-List Memory	Incidental	Same
Factor 4		
Word-List Memory	Intentional	Y > M > O > O-O
Event-List Memory	Incidental	Same
Frequency judgment	Incidental	Y = M > O = O-O
Intrusions	Incidental	Negligible trends

Symbols: = means negligible or nonsignificant;
> means large and significant;
>> means largest significant difference.